



FRENCH-JAPANESE SEMINAR FOR  
COOPERATION ON HYDROGEN  
DEVELOPMENT

# **Hydrogen from regional energy management to global network of renewable production**

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# Advantages of Hydrogen

## Energy problem in Japan

### Low energy self-sufficiency rate



### Unsatisfactory CO<sub>2</sub> emissions

	Country	Billion t	%
1	China	9.3	28.3
2	USA	5.2	15.8
3	India	2.0	6.2
4	Russia	1.5	4.8
<b>5</b>	<b>JAPAN</b>	<b>1.2</b>	<b>3.6</b>
6	Germany	0.7	2.1

### Unstable renewable energy



## Advantages of hydrogen energy

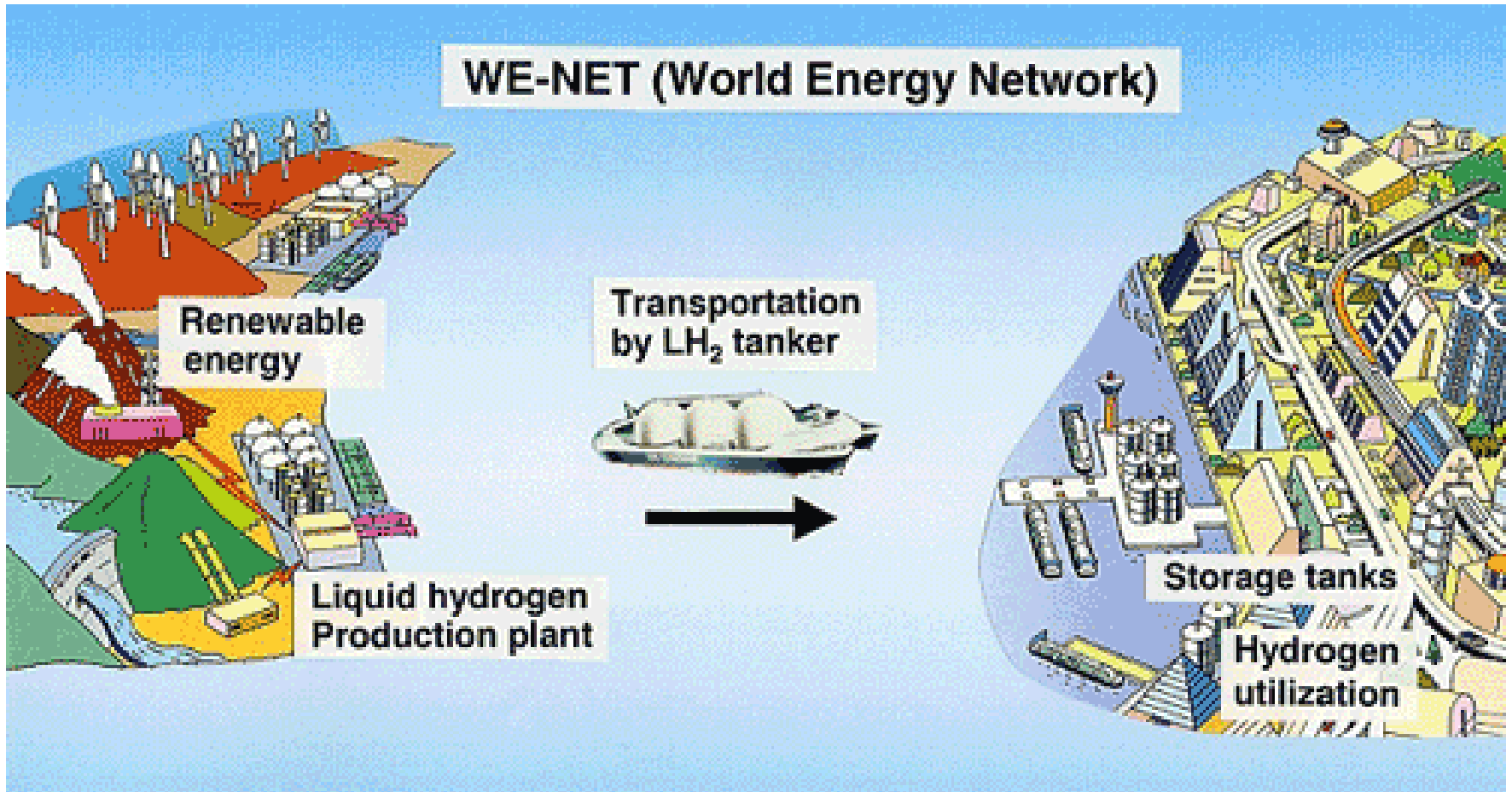
- 1) High self-sufficient energy rate
- 2) Zero CO<sub>2</sub> emission
- 3) High energy density and long term energy storage

Stable energy converted from renewable energy

High energy conversion efficiency, long term storage

# WE-NET (World Energy Network : 1993-2002)

International cooperation in research and development of clean energy system with particular emphasis on hydrogen



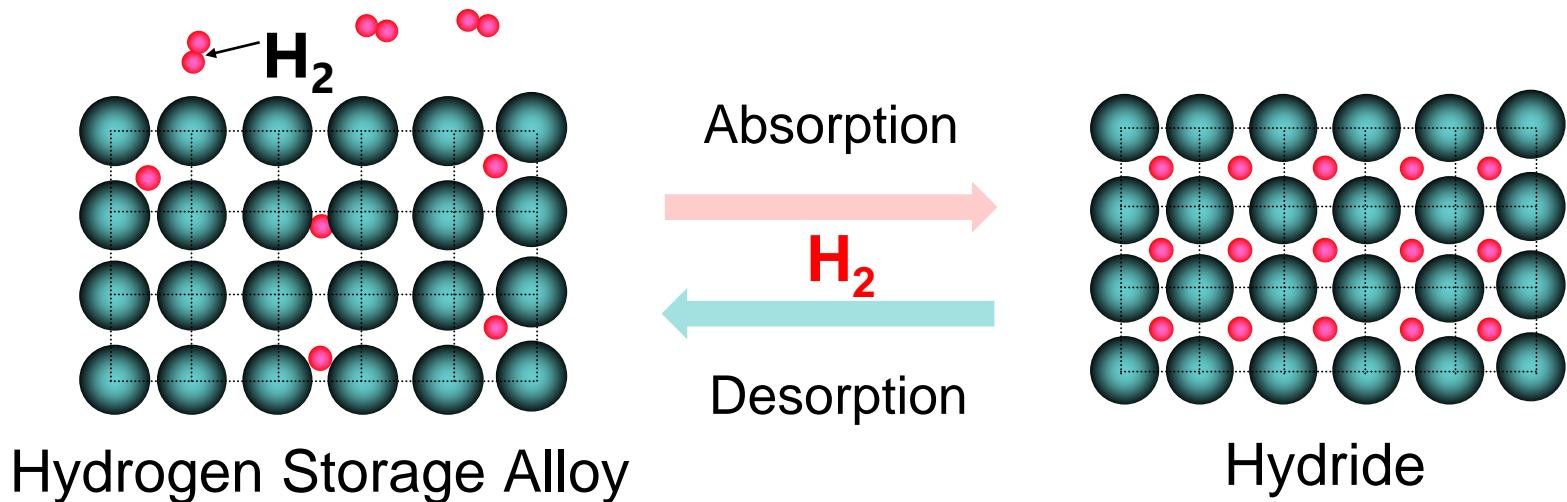
# WE-NET (1993-2002)



- |                            |                                   |
|----------------------------|-----------------------------------|
| 1. Liquid-hydrogen Station | 5. Hydrogen Bus                   |
| 2. Hydrogen Aircraft       | 6. Hydrogen Combustion Generation |
| 3. Hydrogen Storage Tank   | 7. Hydrogen (Transport) Tanker    |
| 4. Energy Consumer Site    | 8. Hydrogen Car                   |

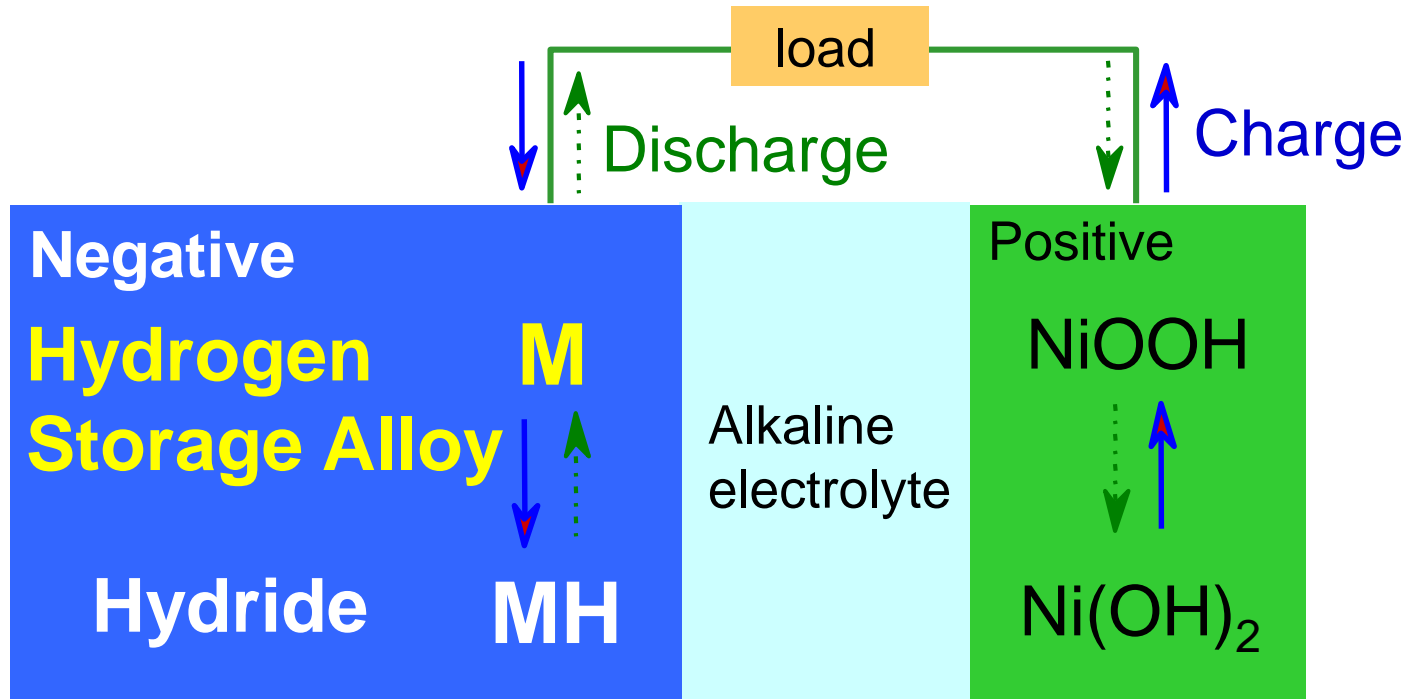
# Hydrogen Storage alloy

- Hydrogen storage alloys can store large amounts of hydrogen as an energy source safely and easily.
- Hydrogen storage alloys are metallic materials that reversibly absorb and desorb large amounts of hydrogen in gas phase.



Hydrogen absorption Mechanism of hydrogen storage alloy

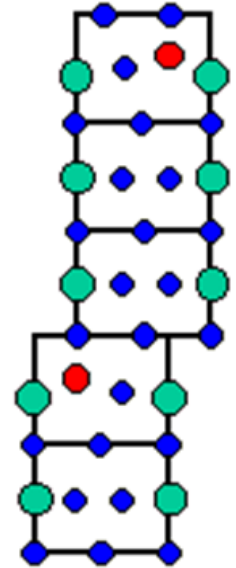
# Nickel Hydride Battery



# La-Mg-Ni Alloy : Superlattice alloy



Journal of Alloys and Compounds  
Volume 311, Issue 2, 26 October 2000, Pages L5-L7



Letter

Hydrogen storage properties of new ternary system alloys:  $\text{La}_2\text{MgNi}_9$ ,  $\text{La}_5\text{Mg}_2\text{Ni}_{23}$ ,  $\text{La}_3\text{MgNi}_{14}$

T Kohno <sup>a</sup>, H Yoshida <sup>b</sup>, F Kawashima <sup>c</sup>, T Inaba <sup>b</sup>, I Sakai <sup>b</sup>, M Yamamoto <sup>b</sup>, M Kanda <sup>a</sup>

**La-Mg-Ni<sub>3-3.5</sub> type alloy**: Stacked by AB<sub>5</sub>, AB<sub>2</sub> unit  
→ **discovered in 1997, published in 2000**

# Nickel Hydride Battery

## eneloop (Sanyo→Panasonic)

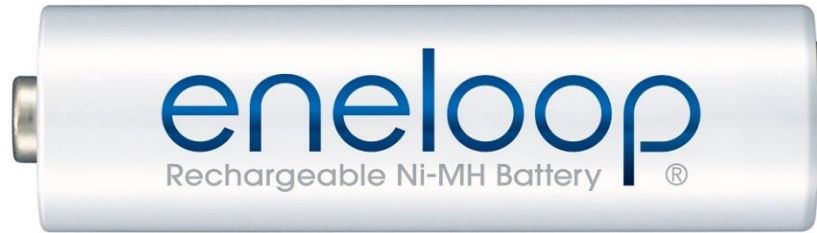
1<sup>st</sup> Nov 2005

Chemical decomposition of the cathode has been reduced substantially by the use of a [new superlattice alloy](#). As an additional benefit the [superlattice alloy increases the electrical capacity of the battery](#) and reduces the internal resistance, which allows higher discharge currents.





# Nickel Hydride Battery



HV  
Hybrid Vehicle



# Volume of 4 kg hydrogen

**Figure 1** Volume of 4 kg of hydrogen compacted in different ways, with size relative to the size of a car. (Image of car courtesy of Toyota press information, 33rd Tokyo Motor Show, 1999.)



$Mg_2NiH_4$

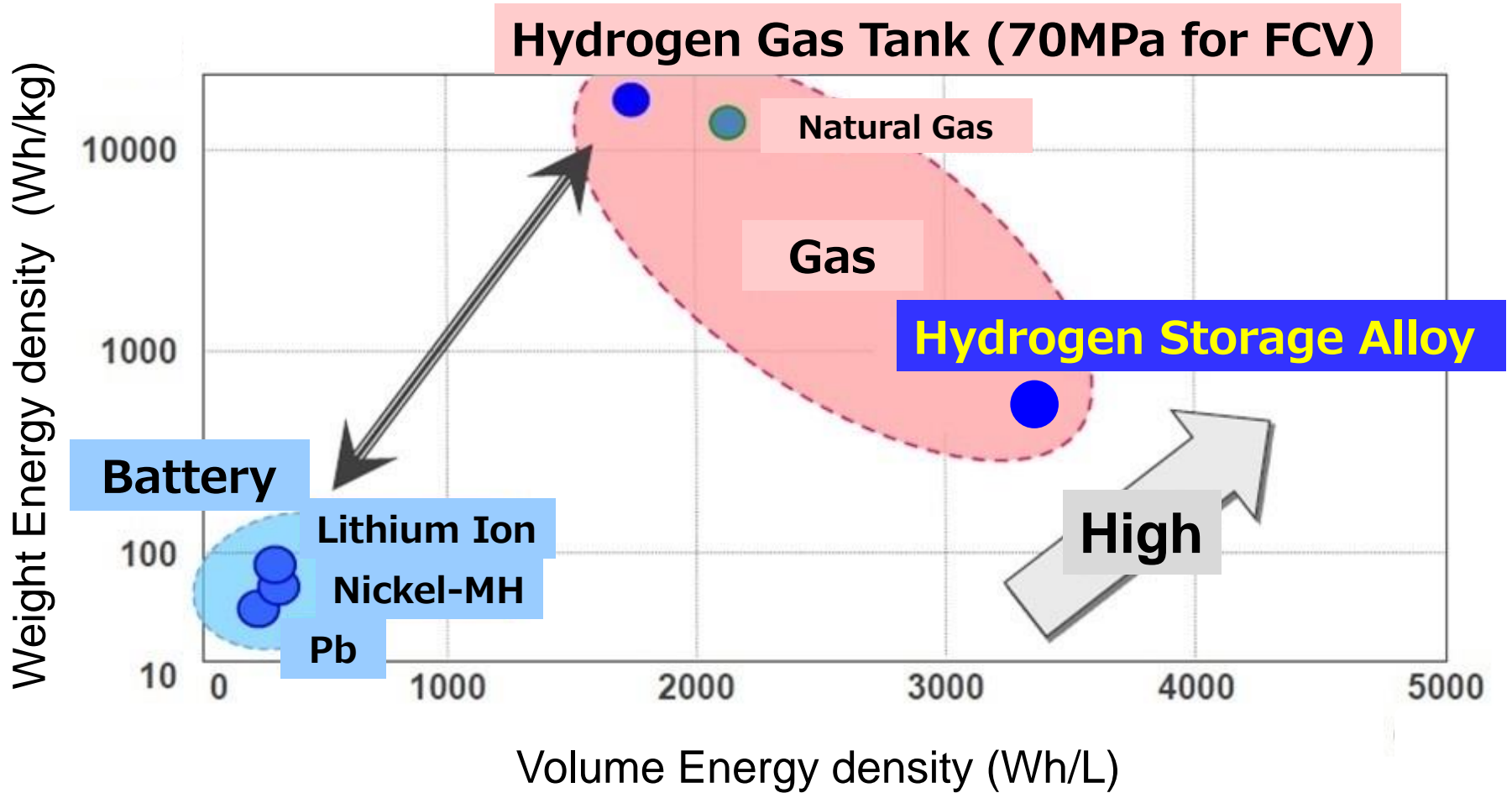
$LaNi_5H_6$

$H_2$ (liquid)

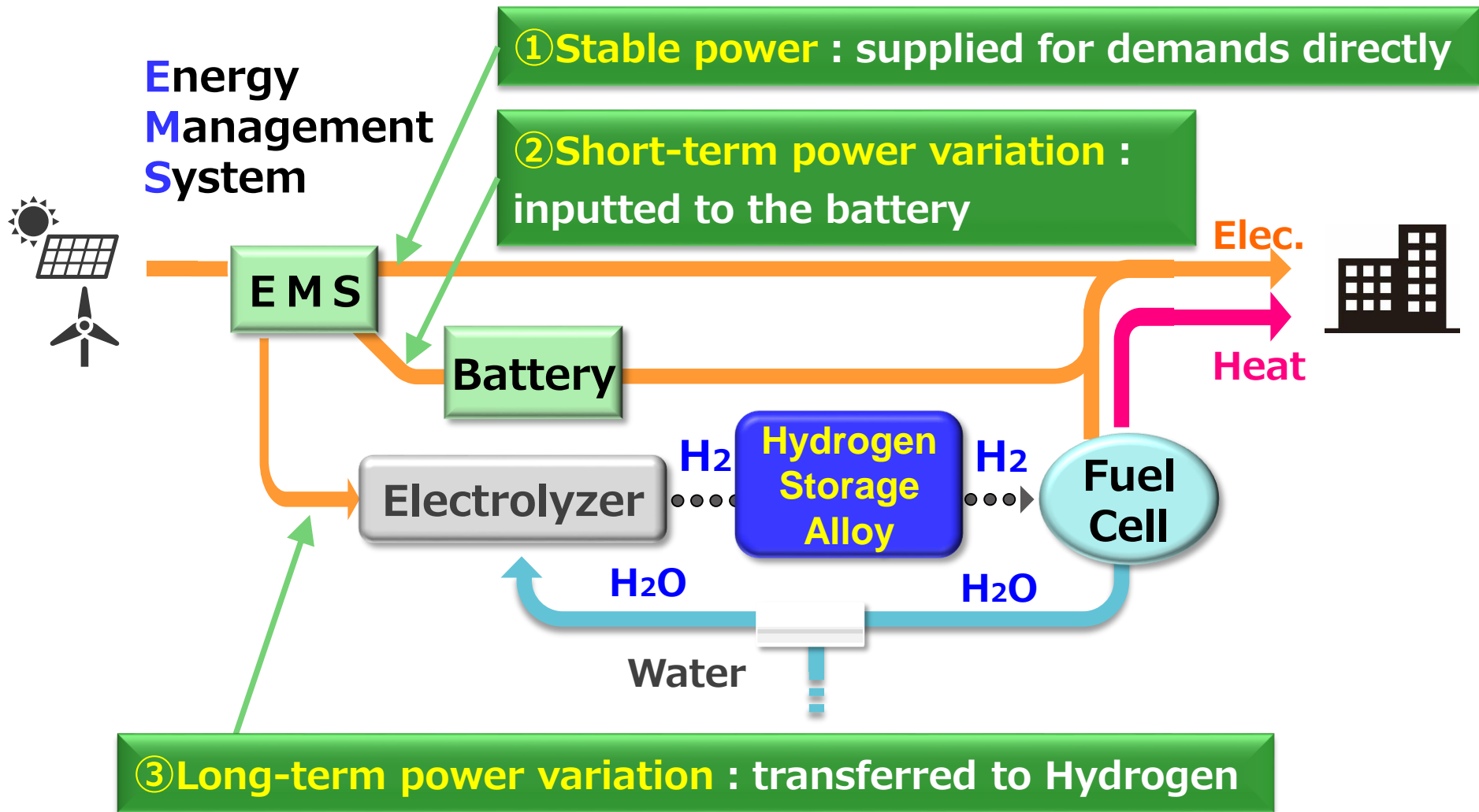
$H_2$ (200bar)

**Hydrogen Storage Alloy**

# Energy Density of Batteries and Hydrogen



# Hydrogen Energy System



# Large MH tank system for the energy system



item	specification
Design Pressure	0.9MPaG
Hydrogen Content	1,000Nm <sup>3</sup> class (1.5MWh)
<b>Alloy Weight</b>	7.2ton (800kgx9tank) <b>AB<sub>5</sub> alloy</b>
Unit Size	W1,800xL3,150 x H2,145mm
Tank Size	Φ342x2,852mm x 9tank
Gross Weight	14ton

# Tohoku Electric Power Company project

To evaluate hydrogen in **overcoming fluctuations from PV**, Tohoku electric power company is using the system from 2017.

It consists of solar power system (50kW),

- ② H<sub>2</sub> production equipment (5Nm<sup>3</sup>/h)
- ③ **H<sub>2</sub> storage alloy tank (220Nm<sup>3</sup>, 300kWh)**
- ④ H<sub>2</sub> fuel cell (9.9kW)
- ⑤ Secondary battery (50kW, 67kWh)



# Disaster prevention energy system

Hydrogen Energy System will be able to provide energy supply under disaster conditions.

In day-to-day operations, it will supply energy to the electronic display of stadium, Rakuten FM TOHOKU radio station, and the light near the baseball stadium.

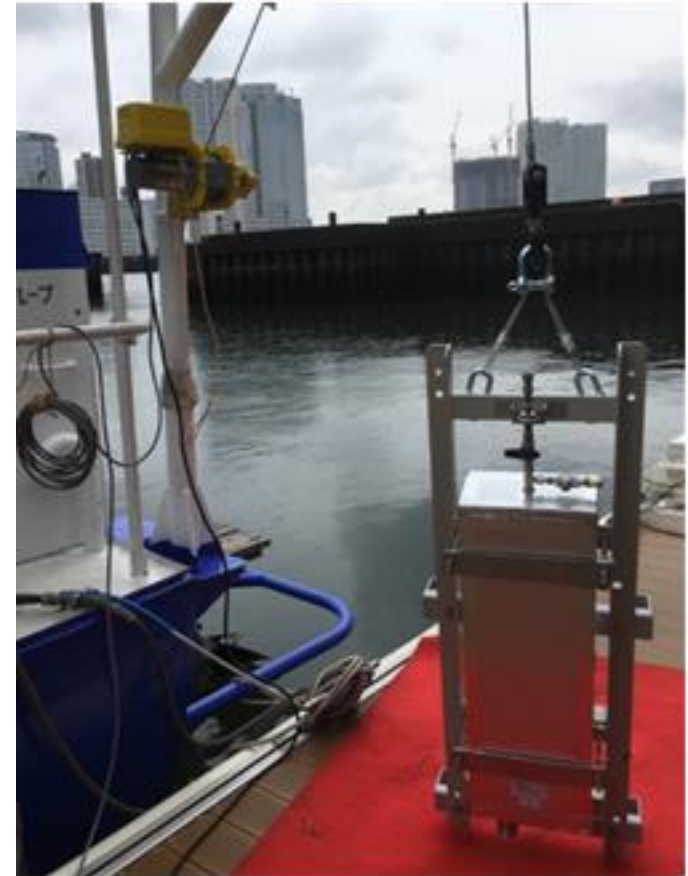


# NEW Hydrogen Storage Alloy Tank for FC ship

Thermocouple Connector

Hydrogen remaining quantity meter

**Hydrogen  
Storage  
Alloy  
Tank**

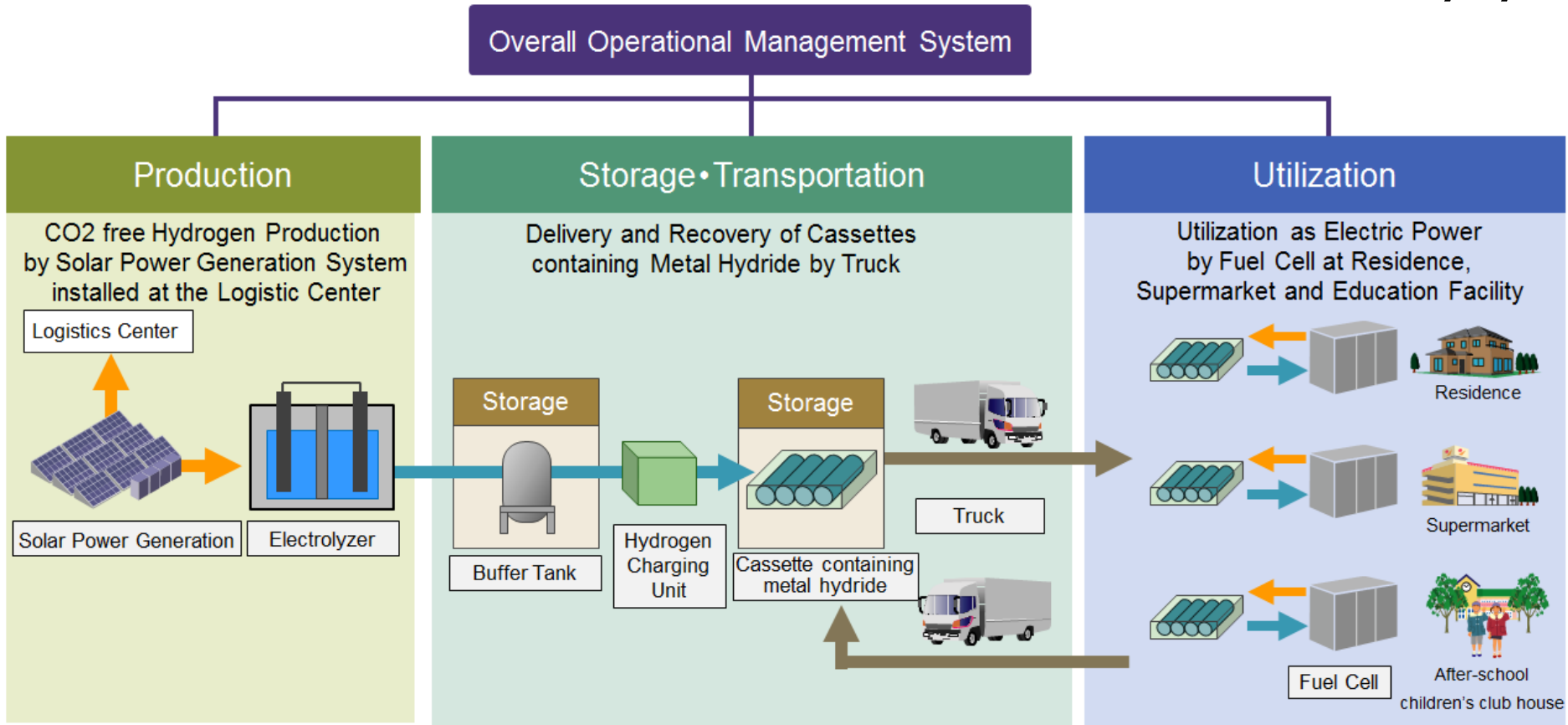


Warm water tube

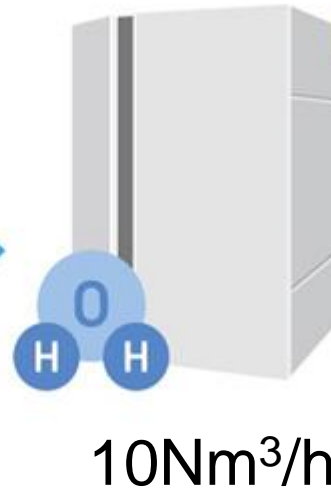
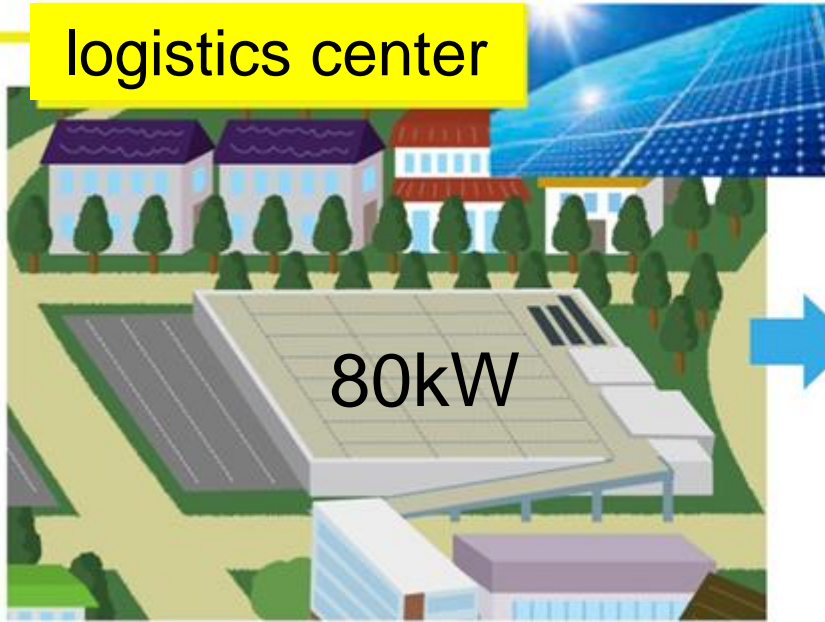


# Low Carbon Hydrogen Supply Chain in Tomiya City, Miyagi (Tohoku)

2018/8/4

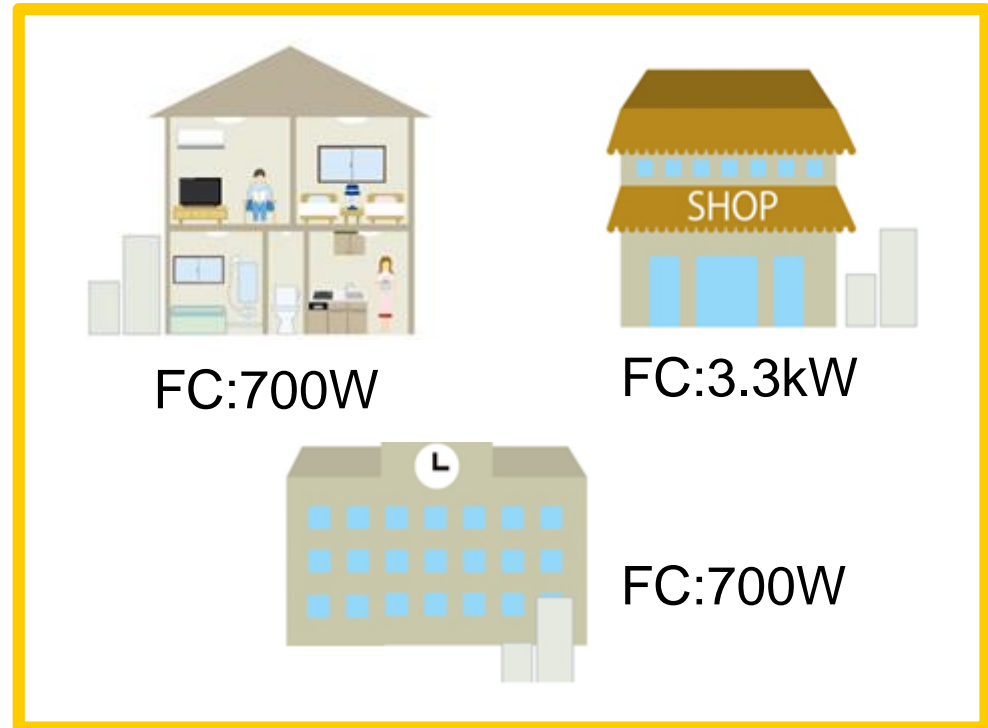
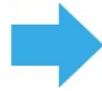


logistics center



Hydrogen  
Storage  
Alloy

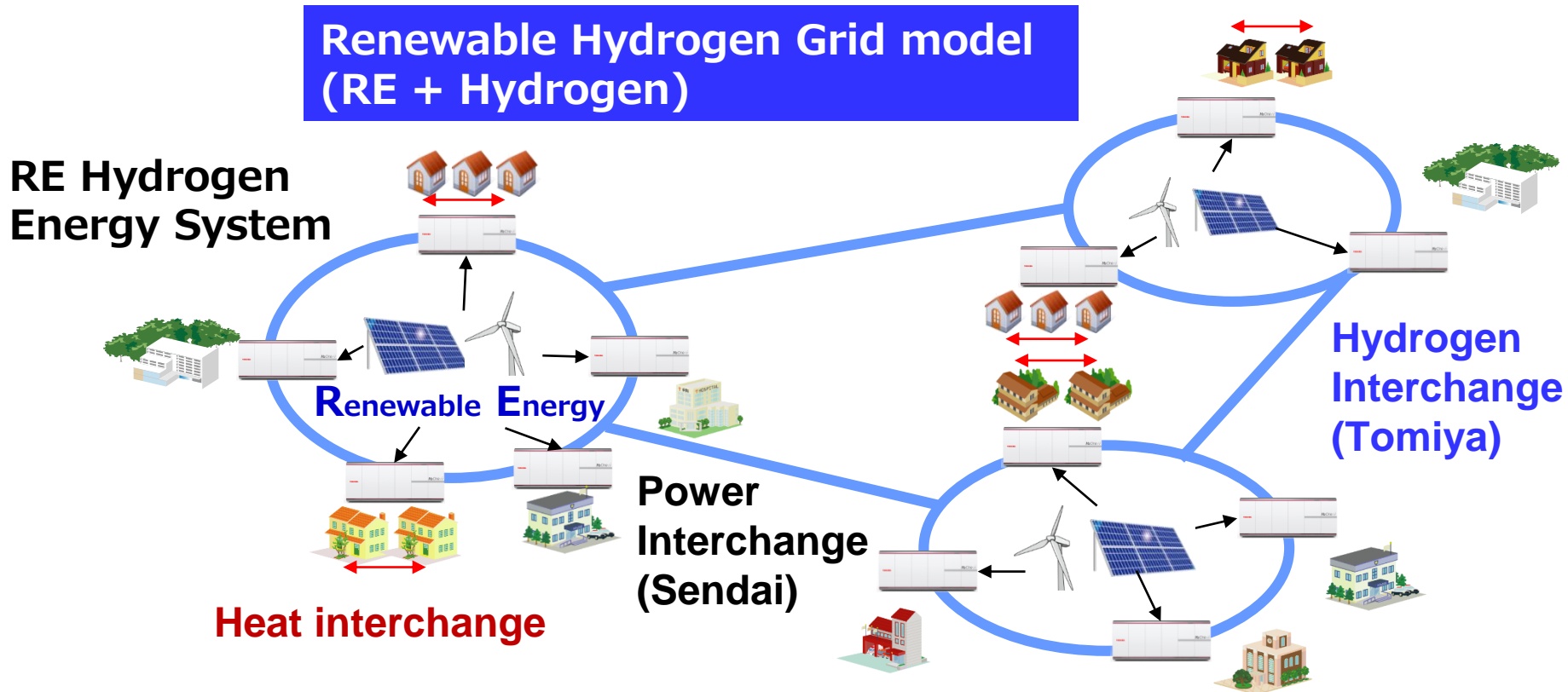
This Demonstration used the existing solar power generation system installed at the logistics center of Miyagi COOP. Solar power is transformed to hydrogen by an electrolyzer, and then stored in the cassettes containing **Hydrogen Storage Alloy**.



Hydrogen Storage Alloy Cassettes will be delivered through an existing distribution network to three family houses, COOP supermarkets and Children's Club. After delivery, the cassette will be attached to a pure Hydrogen Fuel Cell and converted to power and heat that the users can utilize as energy.

# Regional Energy Management System

- 1) Energy serving using Renewable Energy only
- 2) Lower cost compared to fossil fuels
- 3) High packing density : Hydrogen Storage Alloy

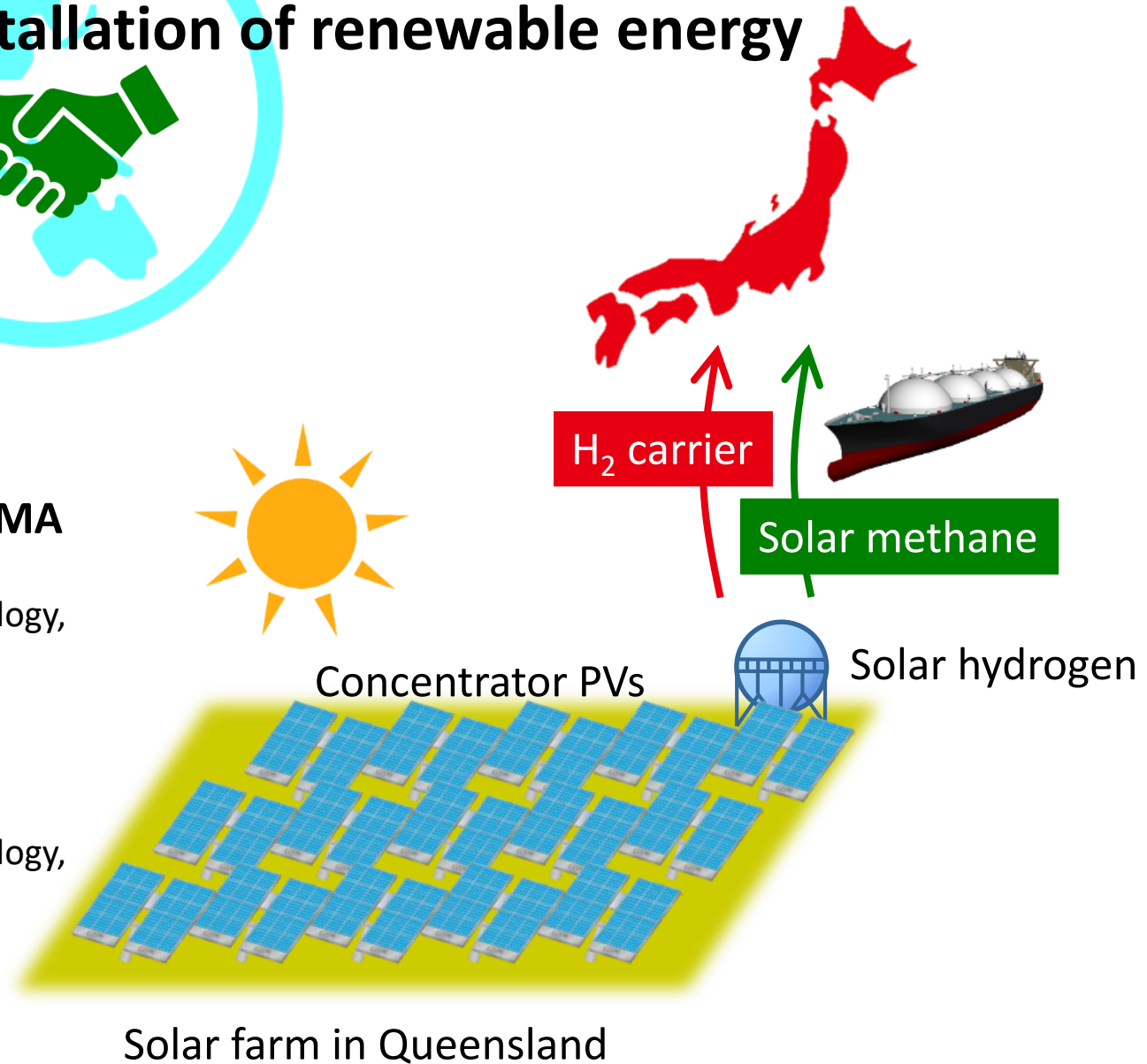


# A global network of hydrogen for disruptive installation of renewable energy

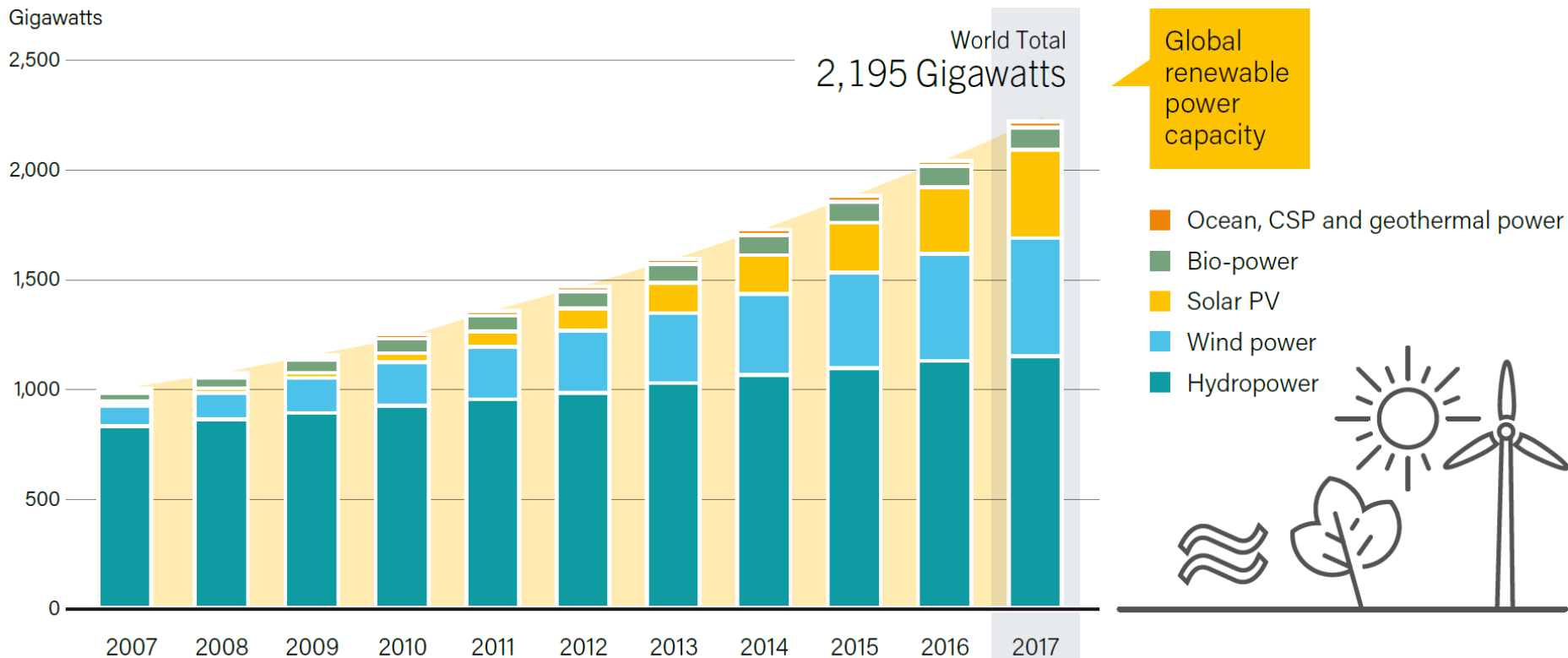


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# Capacity of renewable electricity



REN21. 2018. Renewables 2018 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-9818911-3-3

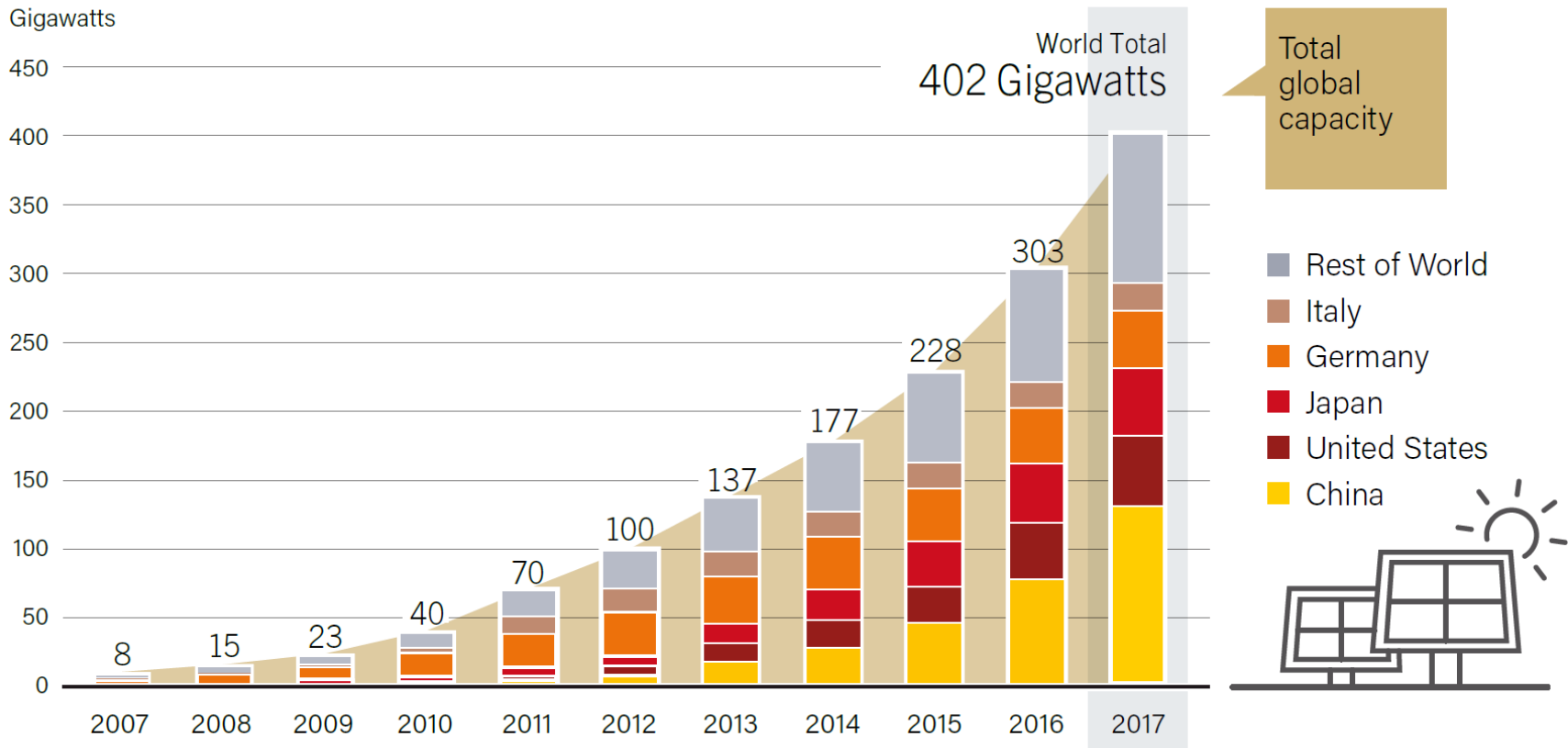
RE : Solar PV + wind power

- Rapid growth in capacity

- Remaining large potential for installation

# Solar PV global capacity

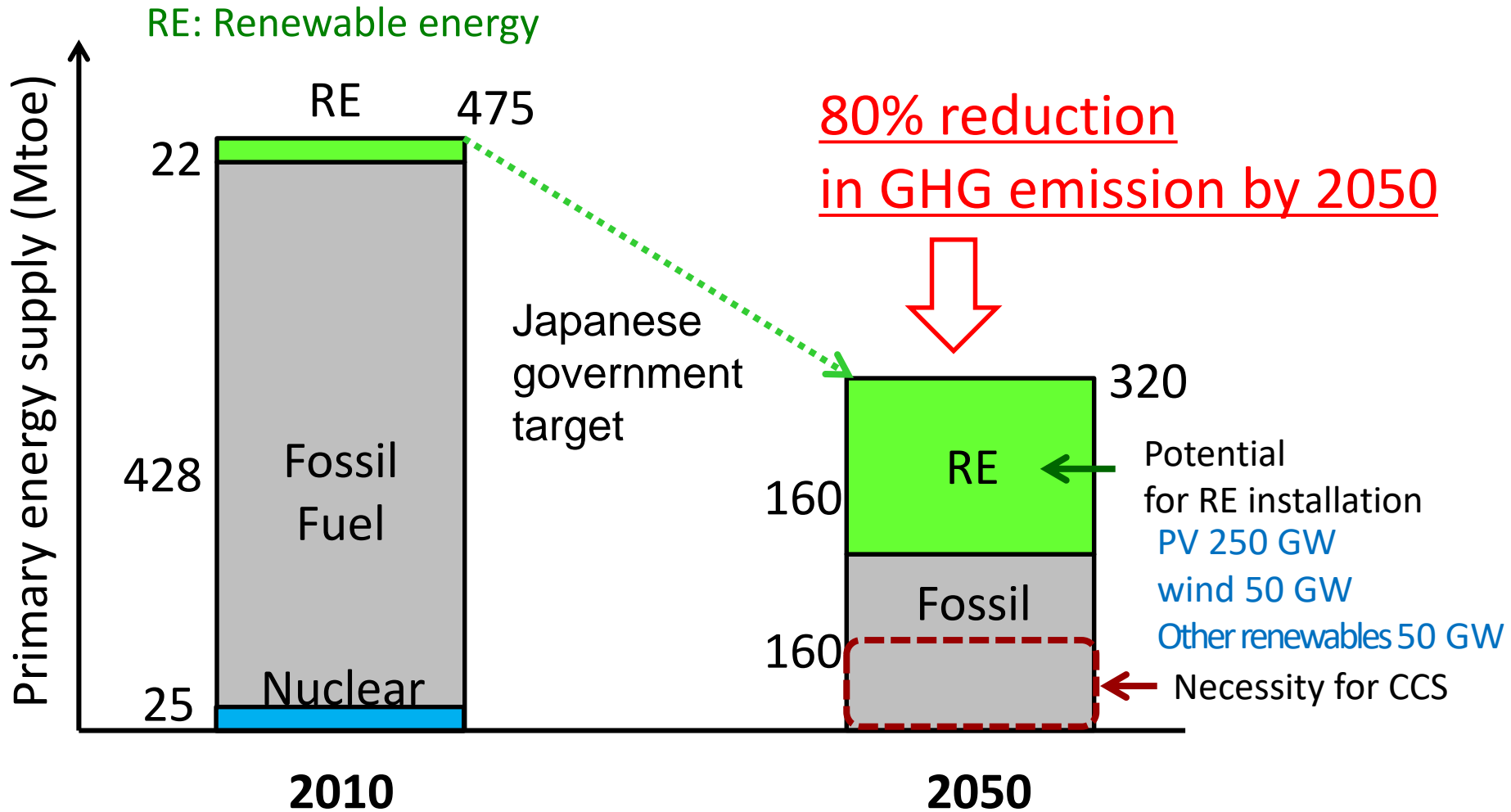
FIGURE 25. Solar PV Global Capacity, by Country or Region, 2007-2017



REN21. 2018. Renewables 2018 Global Status Report (Paris: REN21 Secretariat). ISBN 978-3-9818911-3-3

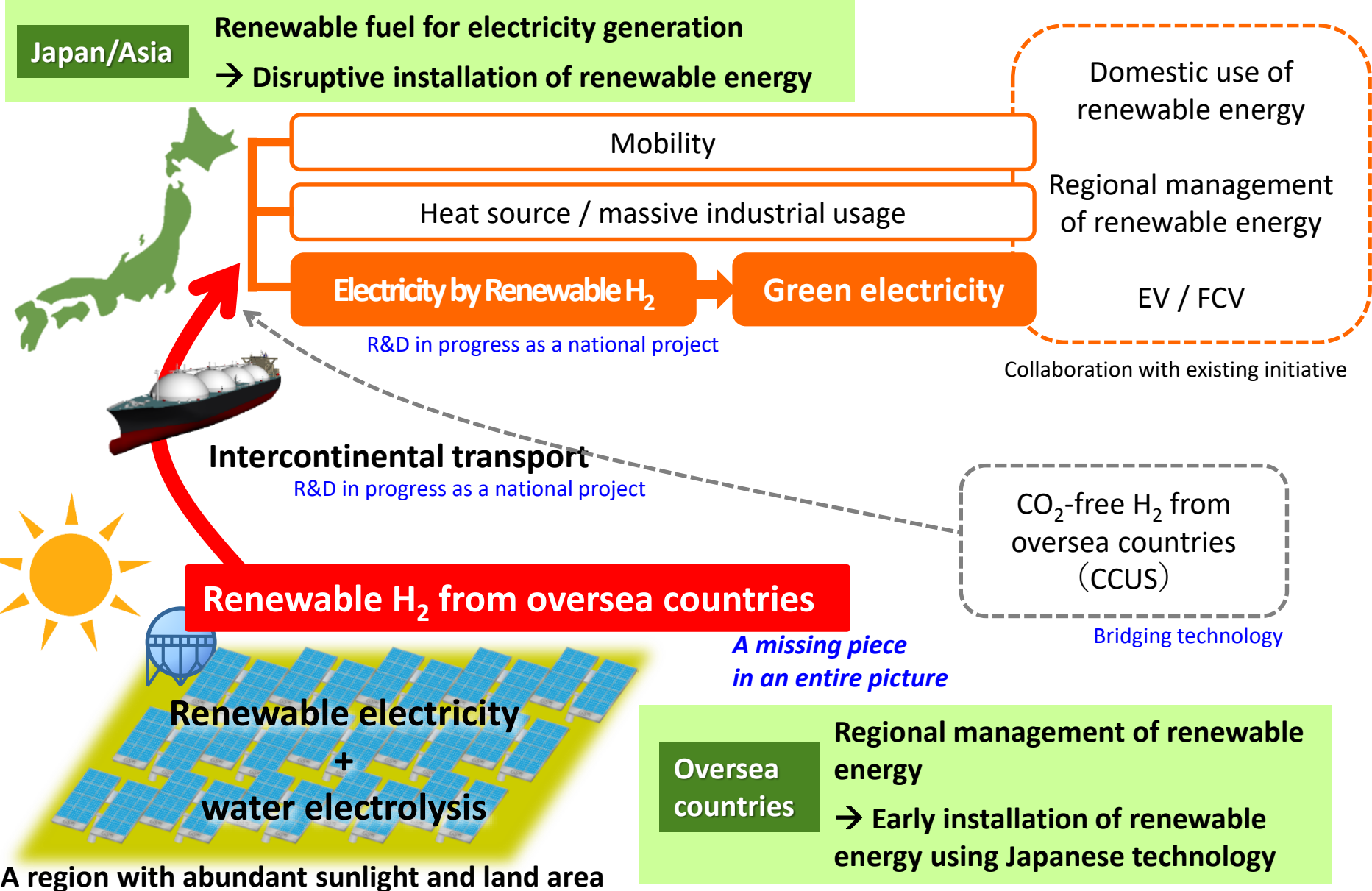
The minimum electricity price of PV : ca. 2¢/kWh

# Decarbonization towards 2050 in Japan

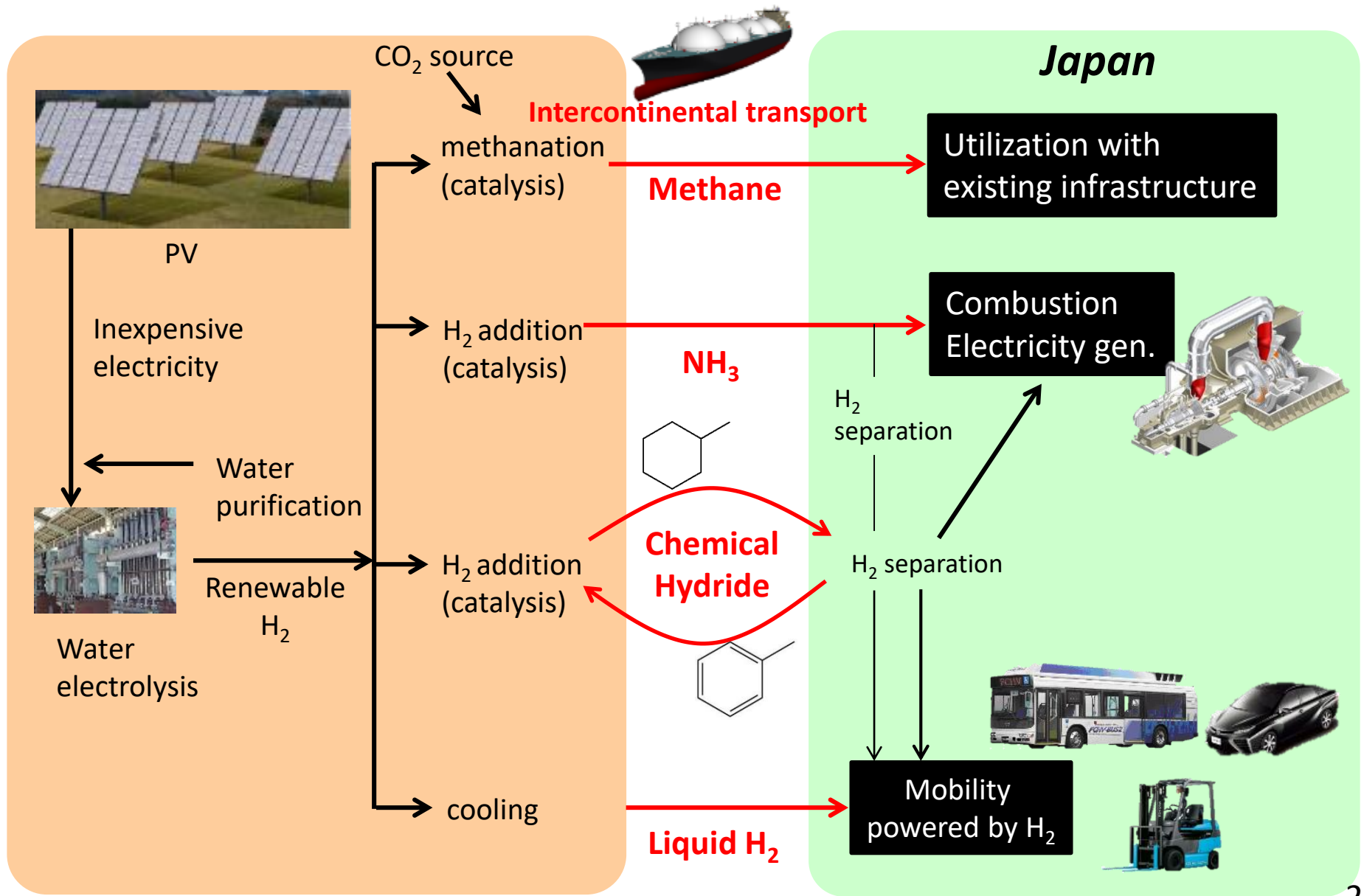


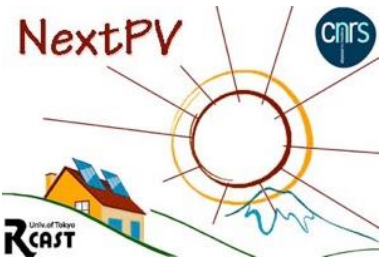


# Targeted energy system



# Intercontinental hydrogen transport and usage





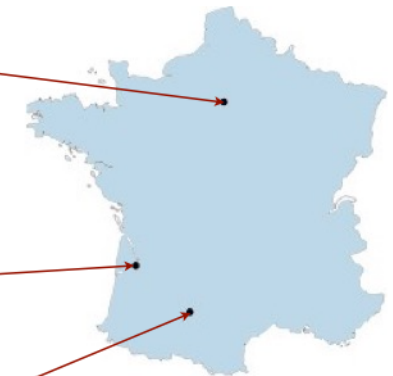
NextPV is an International Joint Laboratory on photovoltaic cells, operated by the French CNRS - Institute for Engineering and Systems Sciences (INSIS), Institute of Chemistry (INC), by The University of Bordeaux and by the Research Center for Advanced Science and Technology (RCAST), The University of Tokyo.



## France - Japan Joint Forum on Solar Energy

- ★ Institut de Développement sur l'Energie Photovoltaïque (IRDEP) <sup>EP\*</sup>
- ★ Institut Lavoisier Versailles (ILV) <sup>EP\*</sup>
- ★ Laboratoire de Physique des Interfaces et Couches Minces (LPICM) <sup>EP\*</sup>
- ★ Laboratoire de Photonique et de Nanostructures (LPN) <sup>EP\*</sup>
- ★ Laboratoire de Génie Electrique de Paris (LGEPE) <sup>EP\*</sup>

At FedPV:



At Bordeaux University:

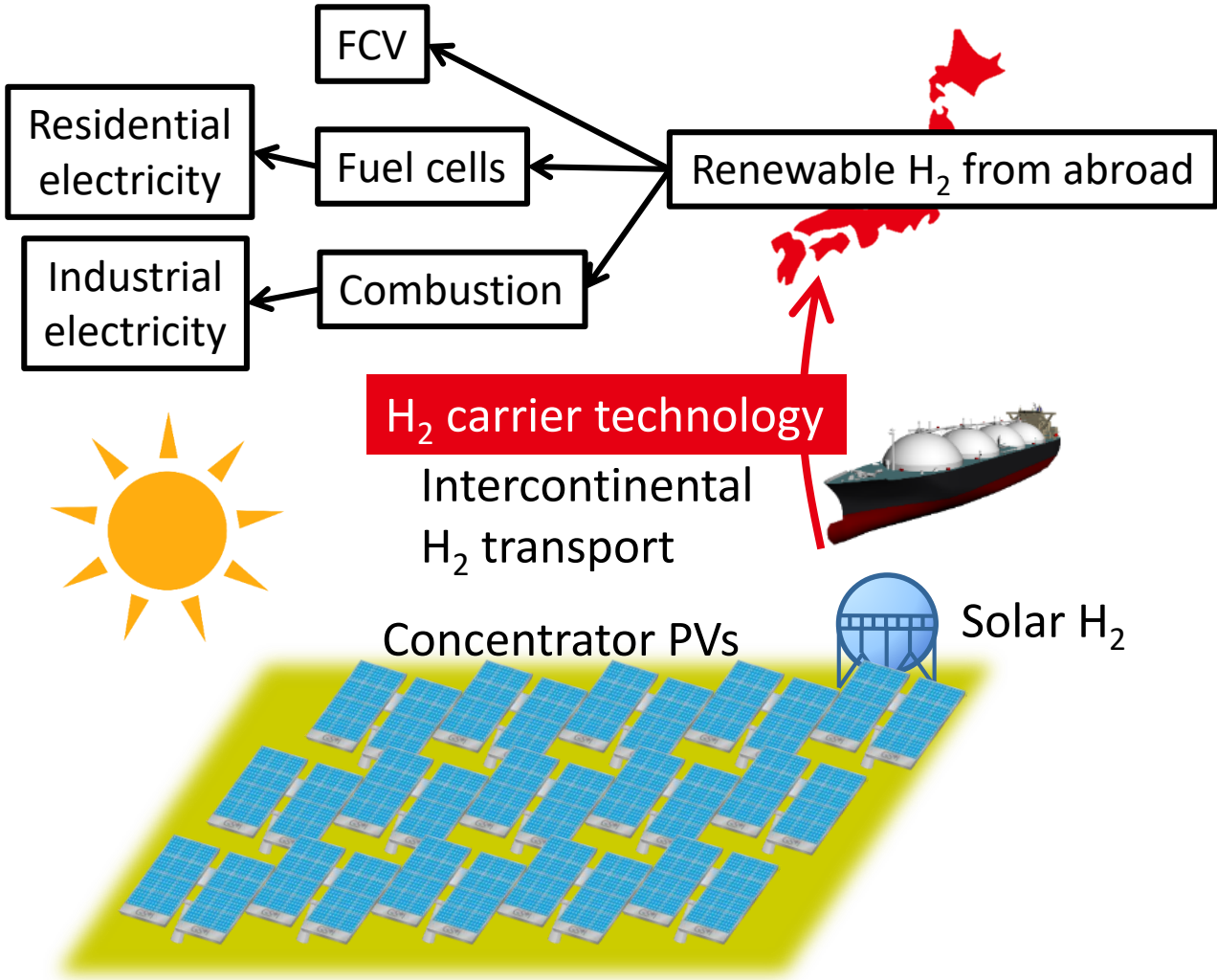
- ★ Laboratoire de Chimie des Polymères Organiques (LCPO) <sup>EP\*</sup>
- ★ Laboratoire d'Intégration du Matériau au Système (IMS) <sup>EP\*</sup>
- ★ Institut des Sciences Moléculaires (ISM) <sup>EP\*</sup>

At Toulouse University:

- ★ Laboratoire PLASma et Conversion d'Energie (LAPLACE) <sup>EP\*</sup>



# Overseas transport of renewable H<sub>2</sub>



The region with high solar irradiance